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TRANSLATION

I, Yuko Mitsui, residing at 4-6-10, Higashikoigakubo, Kokubunji-shi, Tokyo, Japan, state:

that I know well both the Japanese and English languages,

that I translated, from Japanese into English, Japanese Patent Application No. 2002-365138, filed on December 17, 2002, and

that the attached English translation is a true and accurate translation to the best of my knowledge and belief.

Dated: July 11, 2005

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[Document] SPECIFICATION

[Title of the Invention] MEASURING APPARATUS AND MEASURING METHOD FOR JITTER

[What is claimed is:]

[Claim 1] A jitter measuring apparatus comprising:

clock generating means (21) for generating a clock signal having a predetermined frequency; and

pattern generating means (22) for outputting a data signal having a predetermined pattern in which one frame is configured from a predetermined bit length, so as to be synchronized with the clock signal;

waveform information acquiring means (23, 32) for receiving the data signal outputted from the pattern generating means, receiving the clock signal outputted from the clock generating means, and acquiring information of waveform in the same time domain of the data signal to be measured and the clock signal;

averaging processing means (24, 32) for carrying out averaging processing on the waveform acquired by the waveform information acquiring means;

phase difference detecting means (25) for determining the per-bit phase difference between the data signal to be measured and the clock signal, based on the waveform information averaged by the averaging processing unit;

band limiting processing means (26) for carrying out predetermined band limiting processing on information of the per-bit phase difference obtained by the phase difference detecting means; and

measured result outputting means (27) for outputting the

phase difference information on which the band limiting processing is carried out by the band limiting processing means, as pattern dependent jitter.

[Claim 2] The jitter measuring apparatus according to claim 1, characterized in that the pattern generating means is configured to output a frame synchronization signal synchronized with data output timing at an arbitrary bit position in one frame of the data signal to be outputted, to the waveform information acquiring means, and

the waveform information acquiring means is configured to acquire the waveform information of the data signal to be measured and the clock signal by using the timing when the frame synchronization signal is inputted as a standard timing.

[Claim 3] The jitter measuring apparatus according to claim 2, characterized in that the waveform information acquiring means and the averaging processing means are configured from a sampling oscilloscope.

[Claim 4] A jitter measuring method comprising the steps of:

inputting the data signal which is synchronized with a clock signal having a predetermined frequency, and which has a predetermined pattern of a predetermined bit length, to a measuring object (S1, S11);

acquiring waveform information in the same time domain of the data signal to be measured and the clock signal outputted from the measuring object(S2, S12);

carrying out averaging processing on the waveform acquired by the acquiring of the waveform information

(S3, S13);

detecting phase differences of the data signal to be measured and the clock signal, for each bit of the data signal to be measured, based on the waveform information obtained by the averaging processing (S4, S14);

carrying out predetermined band limiting processing on the phase difference information detected for each bit (S5, S17); and

outputting the phase difference information on which the predetermined band limiting processing is carried out, as pattern dependent jitter (S6, S18).

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a technique for measuring pattern dependent jitter which arises in dependence on a pattern of a data signal among jitter components included in the data signal.

[0002]

[Prior Art]

In a data transmission system, when fluctuation (jitter) in the phase of the data signal is large, the data signal cannot be normally transmitted.

[0003]

Therefore, it is necessary to measure in advance the jitter characteristics of the data transmission system and equipment configuring the system.

[0004]

FIG. 10 shows a configuration of a conventional jitter measuring apparatus 10 used for such an object. In FIG. 10, a clock generating means 11 outputs a clock signal CK having a predetermined frequency, and a pattern generating means 12 outputs a data signal Dt which is synchronized with the clock signal CK, and which has a predetermined pattern having a predetermined bit (N) length.

[0005]

A measuring object 1 is, for example, a clock/data recovery circuit used for a data transmission system, and outputs the data signal Dt from the pattern generating means 12.

[0006]

The data signal Dr outputted from the measuring object 1 is inputted to a waveform observing device 13 as a data signal to be measured.

[0007]

The waveform observing device 13 displays waveform of the inputted data signal Dr to be measured.

Namely, the waveform observing device 13 divides the clock signal CK by P (here, P is a number less than the data length N of the data signal Dt), and displays so as to overwrite waveform of the data signal Dr to be measured due to the level displacement timing of the divided signal being made to be the trigger timing.

[0008]

At this time, when a pattern of the data signal Dt is

random, for example, as shown in FIG. 11, waveform in which a rise and a fall intersect in a width of one bit is displayed on the waveform observing device 13.

[0009]

This waveform is called eye-pattern, and when jitter in the data signal Dr to be measured is large, a width W of the intersection of the rise and the fall of the eye-pattern is made large.

[0010]

Accordingly, a jitter amount of the data signal Dr to be measured can be grasped in accordance with the width W of the intersection of the eye-pattern displayed on the waveform observing device 13.

[0011]

Note that a method for determining jitter by observing the eye-pattern of a data signal as described above is described in, for example, Patent Document 1.

[0012]

[Patent Document 1]

Jpn. Pat. Appln. KOKAI Publication No. 5-145582

[0013]

[Object of the Invention]

However, in the method for measuring jitter based on the width W of the eye-pattern displayed on the waveform observing device 13 as described above, pattern dependent jitter which arises in dependence on a pattern of a data signal cannot be grasped.

[0014]

Namely, as jitters, there are random noise jitter arising due to noise of equipment themselves, external noise, or the like, and pattern dependent jitter arising due to a pattern of a data signal which is transmitted.

[0015]

The pattern dependent jitter is jitter arising due to waveform distortion generated because a DC component cannot pass through when a data transmission passing band of the measuring object 1 is high (several GHz), duty cycle distortion of a data signal, waveform distortion generated because the frequency characteristic of the measuring object 1 is not sufficient for a frequency of the signal which is transmitted, or the like.

[0016]

This pattern dependent jitter is not a serious problem when a data signal has strong random characteristic such as a pseudo-random pattern. However, in a case where the data signal having the predetermined pattern is a data signal in which an unscrambled specific pattern always exists at the head position, such as a frame actually used for data transmission, for example, an SDH frame or a SONET frame, large pattern dependent jitter arises at the frame intervals (for example, 125 μs intervals).

[0017]

Moreover, because the frequency of the pattern dependent jitter arising at this frame intervals is generally within a frequency band stipulated by jitter measurement, the pattern

dependent jitter cannot be measured in distinction from other random noise jitter.

[0018]

Further, in measurement of jitter in dependence on a pattern of a data signal as described above, it is necessary to exactly grasp the relation between the position of data and jitter. However, it is difficult to exactly grasp the relation in the eye-pattern observation as described above.

[0019]

Therefore, realization of a measuring apparatus for jitter and a jitter measuring method which can exactly grasp the pattern dependent jitter has been strongly desired.

[0020]

An object of the present invention is to solve this problem and provide a measuring apparatus and a measuring method for jitter which can exactly grasp the pattern dependent jitter.

[0021]

[Means for Achieving the Object]

In order to achieve the above object, the jitter measuring apparatus according to the present invention as recited in claim 1 comprises:

a clock generating means (21) for generating a clock signal having a predetermined frequency;

a pattern generating means (22) for outputting a data signal having a predetermined pattern in which one frame is configured from a predetermined bit, so as to be synchronized with the clock signal;

a waveform information acquiring means (23, 32) for receiving the data signal outputted from the pattern generating unit as a data signal to be measured, and receiving the clock signal outputted from the clock generating unit, and for acquiring information of waveform in the same time domain of the data signal to be measured and the clock signal;

an averaging processing means (24, 32) for carrying out averaging processing on the waveform acquired by the waveform information acquiring means;

a phase difference detecting means (25) for determining the per-bit phase difference between the data signal to be measured and the clock signal, based on the waveform information averaged by the averaging processing means;

a band limiting processing means (26) for carrying out predetermined band limiting processing on information of the per-bit phase difference obtained by the phase difference detecting means; and

a measured result outputting means (27) for outputting the phase difference information on which the band limiting processing is carried out by the band limiting processing means, as pattern dependent jitter.

[0022]

The jitter measuring apparatus according to the present invention as recited in claim 2 is such that, in the jitter measuring apparatus according to claim 1, the pattern generating unit is configured to output a frame synchronization signal synchronized with data output timing at an arbitrary bit position in one frame of the outputted data signal, to the

waveform information acquiring means, and the waveform information acquiring means is configured to acquire the waveform information of the data signal to be measured and the clock signal by using the timing when the frame synchronization signal is inputted as a standard timing.

[0023]

The jitter measuring apparatus according to the present invention as recited in claim 3 is such that, in the jitter measuring apparatus according to claim 2, the waveform information acquiring means and the averaging processing means are each configured by a sampling oscilloscope.

[0024]

The jitter measuring method according to the present invention as recited in claim 4 comprises the following steps:

inputting the data signal which is synchronized with a clock signal having a predetermined frequency, and which has a predetermined pattern of a predetermined bit length, to a measuring object (S1, S11);

acquiring waveform information in the same time domain of the data signal to be measured and the clock signal outputted from the measuring object (S2, S12);

carrying out averaging processing on the acquired waveform (S3, S13);

detecting phase differences of the data signal to be measured and the clock signal, for each bit of the data signal to be measured, based on the wave information obtained by the averaging processing (S4, S14);

carrying out predetermined band limiting processing on

the phase difference information detected for each bit (S5, S17); and

outputting the phase difference information on which the predetermined band limiting processing is carried out, as pattern dependent jitter (S6, S18).

[0025]

[Embodiments of the Invention]

Hereinafter, embodiments of the present invention will be described with reference to the drawings.

FIG. 1 shows a basic configuration of a jitter measuring apparatus 20 according to a first embodiment to which the present invention is applied.

[0026]

In FIG. 1, a clock generating unit 21 outputs a clock signal CK having a predetermined frequency corresponding to a data transmission rate of a measuring object 1 (for example, about 2.5 Gbps or about 9.95 Gbps).

[0027]

A pattern generating means 22 repeatedly outputs a data signal Dt having a predetermined pattern in which one frame (for example, the SDH/SONET frame described above) is configured from a predetermined bits N so as to synchronize with the clock signal CK. Further, the pattern generating means 22 outputs a frame synchronization signal S synchronizing with the data output timing at a predetermined bit position (for example, the head position) of the data signal Dt.

[0028]

Note that, here, the data signal Dt is an electric signal.

However, the data signal Dt may be an optical data signal as will be described later.

[0029]

Further, the above-described clock generating means 21 and pattern generating means 22 can be configured from an integrated-type pattern generator (as described above, the data signal to be outputted may be any of an electric signal and an optical signal) having the functions thereof.

[0030]

The data signal Dt is inputted to the measuring object 1 via an output terminal 20a.

The measuring object 1 is various types of equipment used for a data transmission system, and here, the measuring object 1 will be described as a clock/data reproducer which waveform-shapes and outputs the data signal Dt in the same way as in the above description.

[0031]

A data signal Dr to be measured outputted from the measuring object 1 is inputted to a waveform information acquiring means 23 via an input terminal 20b.

[0032]

The waveform information acquiring means 23 acquires plural (M) frames of waveform information (for example, M = 16) in the same time domain of the data signal Dr to be measured and the clock signal CK based on the input timing of the frame synchronization signal S.

[0033]

An averaging processing means 24 carries out averaging

processing on the degree M with respect to the waveform acquired by the waveform information acquiring means 23.

[0034]

Due to this averaging processing, the random noise jitter components included in the data signal Dr to be measured and the clock signal CK are eliminated, and only the components of pattern dependent jitters remain.

[0035]

The waveform information acquiring means 23 and the averaging processing means 24 can be configured by using a digital sampling oscilloscope as will be described later.

[0036]

Based on the waveforms of the data signal Dr to be measured and the clock signal CK averaged by the averaging processing means 24, a phase difference detecting means 25 determines one frame (N bits) of the data signal Dr to be measured by using, as the unit of time, the phase difference, per bit, between the data signal Dr to be measured and the clock signal CK.

[0037]

A band limiting processing means 26 carries out band limiting processing which is determined in advance due to the above-described bit rate with respect to information of the phase difference for each bit detected by the phase difference detecting means 25.

[0038]

For example, in the case of the SDH/SONET described above, when a transmission rate is about 2.5 Gbps, the band limiting

processing of any of 5 kHz to 20 MHz, 12 kHz to 20 MHz, and 1 MHz to 20 MHz is carried out. Further, when a transmission rate is about 9.95 Gbps, the band limiting processing of any of 20 kHz to 80 MHz, 50 kHz to 80 MHz, and 4 MHz to 80 MHz is carried out.

[0039]

A measured result outputting means 27 is configured from a transmitter for carrying out transmission of information to an indicator, a printer, or an external device, or the like, and the information of the phase differences to which band limiting processing is applied by the band limiting processing means 26 is display-outputted, printed-out, or outputted to an external device, as a pattern dependent jitter Jdp which the measuring object 1 generates with respect to the data signal Dt.

[0040]

Next, the operations of the jitter measuring apparatus 20 will be described.

With respect to the clock signal CK, as shown in FIG. 2(b), which is outputted from the clock generating means 21, the frame synchronization signal S and the data signal Dt (not showed, and for example, the SDH frame data described above) as shown in FIG. 2(a) are outputted from the pattern generating means 22. The data signal Dr to be measured as shown in FIG. 2(c) is outputted from the measuring object 1 which has received the data signal Dt.

[0041]

Note that random noise jitters Jn are included in the clock signal CK, the data signal Dt, the data signal Dr to be

measured, and the frame synchronization signal S.

[0042]

Further, there are cases in which pattern dependent jitter is included in the data signal Dt inputted to the measuring object 1. However, the component of the pattern dependent jitter included in the data signal Dt is eliminated due to the waveform shaping processing at the inside of the clock/data reproducer serving as the measuring object 1.

[0043]

Accordingly, the random noise jitter and the pattern dependent jitter which the measuring object 1 itself (outputting portion) generates are included in the data signal Dr to be measured.

[0044]

Such a data signal Dr to be measured is inputted to the waveform information acquiring means 23 together with the clock signal CK, and the waveform information (information regarding the amplitude values of each time) in the same time domain of the both signals are acquired.

[0045]

Here, the waveform information acquiring means 23 carries out, for example, processing in which the waveform information of the data signal Dr to be measured and the clock signal CK which are inputted during the time from the timing based on the timing when the frame synchronization signal S is inputted until the next frame synchronization signal S is inputted, are acquired, with respect to M frames.

[0046]

The averaging processing means 24 determines one frame of waveform information (only a portion of which is shown in FIGS. 2(d) and 2(e)) of the clock signal CK′ and the data signal Dr′ to be measured from each of which the random noise jitter component has been removed as shown in FIGS. 2(d) and 2(e), by performing averaging processing on the M frames of the waveform information.

[0047]

As shown in FIG. 2(f), the phase difference detecting means 25 determines a phase difference (time difference) $\Delta T(i)$ between the level displacement timing (here, fall edge) of the clock signal CK′ from which the random noise jitter component has been removed and a code boundary of the data signal Dr′ to be measured from which the random noise jitter component has been removed, for each bit, and a phase difference $\Delta T(i)'$ for each bit is determined as follows by correcting the phase differences $\Delta T(2)$, $\Delta T(3)$, …, $\Delta T(N)$ from the second bit on by the bit difference $\Delta T(1)$ of the first bit.

[0048]

$\Delta T(1)' = 0$

$\Delta T(i)' = \Delta T(i) - \Delta T(1)$ $(i = 2, 3, \ldots, N)$

[0049]

Note that detection of each timing is carried out after it is judged whether or not a signal amplitude exceeds a certain threshold value. However, when the code of the data signal Dr′ to be measured does not vary (the same code continues), it is difficult to detect the timing of the code

boundary from the waveform.

[0050]

Then, actually, only when the code of the data signal Dr′ to be measured varies, the timing is detected, and a time difference between the timing and the level displacement timing of the clock signal CK′ is determined as a phase difference. Furthermore, when the code of the data signal Dr′ to be measured does not vary, a phase difference of the previous bit is allocated thereto.

[0051]

The information of the phase differences $\Delta T(1)'$, $\Delta T(2)'$, ..., $\Delta T(N)'$ for one frame obtained in this way are generated due to the pattern dependent jitter, and when one frame of pattern dependent jitter is determined, for example, jitter waveform such as shown in FIG. 3 is obtained.

[0052]

For example, band limiting processing of 4 MHz to 80 MHz corresponding to a bit rate of about 9.95 Gbps is carried out with respect to the jitter waveform by the band limiting processing means 26, jitter waveform such as shown in FIG. 4 is obtained. This band limiting processing has been obtained by converting the jitter waveform for each bit of FIG. 3 into jitter waveform on the time base based on a bit rate, and by carrying out the above-described band limiting by a digital filter.

[0053]

It can be understood that large pattern dependent jitter arises at the head portion of the jitter waveform due to

an unscrambled specific pattern at the head portion of the SDH/SONET frame.

[0054]

As shown in FIG. 4, the measured result outputting means 27 displays the waveform of the jitter on which the band limiting processing has been carried out, on a screen as the pattern dependent jitter which the measuring object 1 generates with respect to the data signal Dt, prints it out, or transmits it to another device.

[0055]

Note that, other than being expressed by using the phase difference as the unit of time as described above, the measured results may be converted into UIpp (unit interval) units and outputted.

[0056]

FIG. 5 is a flowchart shown for explanation of the procedure of a method for measuring pattern dependent jitter described above.

[0057]

First, the data signal Dt having a predetermined N-bit length pattern synchronizing with the clock signal CK having a predetermined frequency is provided to the measuring object 1 (step S1). Next, information of the waveforms in the same time domain of the data signal Dr to be measured outputted from the measuring object 1 and the clock signal CK outputted from the clock generating means 21 are acquired (step S2).

[0058]

Further, averaging processing is carried out on the

acquired waveform by the averaging processing unit 24 (step S3), and whereby random noise jitters are eliminated therefrom. Next, the phase differences $\Delta T(i)'$ between the clock signal CK' and the data signal Dr' to be measured, for one frame, is determined for each bit of the data signal to be measured, based on the waveforms obtained due to the averaging processing (step S4).

[0059]

Subsequently, a predetermined band limiting processing is carried out on determined one frame of the phase difference information (step S5). Next, the pattern dependent jitter of the measuring object 1 is obtained and outputted as a measured result (step S6).

[0060]

In this way, the jitter measuring apparatus 20 and measuring method according to this embodiment measure pattern dependent jitter by acquiring waveform information in the same time domain of the data signal Dr to be measured outputted from the measuring object 1 and the clock signal CK; removing the random noise jitter component by performing averaging processing on the waveform information; determining, for one frame, the per-bit phase difference of the clock signal CK' and the data signal Dr' to be measured from which the noise jitter has been removed; and carrying out predetermined band limiting processing on this phase difference information.

[0061]

Therefore, it is possible to exactly measure only the pattern dependent jitter, which has been impossible in the

eye-pattern observation of a prior art.

[0062]

Further, the relation between the position of a data signal and pattern dependent jitter can be easily grasped.

[0063]

The above description is described with respect to the basic configuration of the jitter measuring apparatus of the present invention. However, next, a configuration example of a further concrete jitter measuring apparatus will be described.

[0064]

A jitter measuring apparatus 20′ shown in FIG. 6 is an apparatus in which an light transmitter (an Electrical-Optical converter) which converts an electric data signal into an optical data signal, and emits it, is made to serve as a measuring object 1. The jitter measuring apparatus 20′ provides the electric data signal Dt to the measuring object 1, and provides the clock signal CK via the output terminal 20c to the measuring object 1.

[0065]

In a case of this type of measuring object 1, namely, the clock signal CK at the inside thereof is delayed so as to be not affected with jitter of a data signal generally inputted, and waveform shaping of the data signal Dt is carried out by using the delayed clock signal, and an optical data signal Dp to be measured obtained is emitted due to intensity of light being modulated by the waveform-shaped signal.

[0066]

Accordingly, even if pattern dependent jitter is included in the data signal Dt outputted from the pattern generating unit 22, the jitter component is made small enough to be ignored due to the above-described waveform shaping processing in the measuring object 1, the pattern dependent jitter included in the data signal Dp to be measured outputted from the measuring object 1 can be considered as the jitter which arose at the measuring object 1 itself (mainly, a modulating portion or an outputting portion).

[0067]

The jitter measuring apparatus 20′ receives the optical data signal Dp to be measured at an input terminal 20d, and converts the data signal Dp to be measured into the electric data signal Dr to be measured by an Optical-Electrical converter 31. Note that, as will be described later, when the sampling oscilloscope 32 has a function that an optical signal is directly received, and is Optical-Electrical converted at the inside thereof, the Optical-Electrical converter 31 is omitted, and the optical data signal Dp to be measured can be directly inputted to the sampling oscilloscope 32.

[0068]

In the jitter measuring apparatus 20′, in place of the above-described waveform information acquiring means 23 and averaging means 24, the digital sampling oscilloscope 32 having a function of acquiring waveform information of a high-speed data signal, and a function of averaging processing on the acquired waveform, is used.

[0069]

The sampling oscilloscope 32 is configured so as to carry out sampling for the clock signal CK and the data signal Dr to be measured inputted, for example, as shown in FIGS. 7(a) and 7(b), at a period Ts (= K•Tf + ΔTr or = K•Tf - ΔTr) which is different by a slight time ΔTr from a period K•Tf which is K times (K is an arbitrary integer, and denotes the case of K = 1 in FIG. 7) of a frame period Tf (given that a period of the clock signal CK is Tc, N•Tc) of the data signal Dt, as shown in FIG. 7(c). As shown in FIGS. 7(d) and 7(e), the sampling oscilloscope 32 determines the waveform information Hc and Hd of the clock signal CK and the data signal Dr to be measured due to the time resolution of ΔTr.

[0070]

The sampling oscilloscope 32 has an external trigger function in which acquisition of waveform information can be started from the timing which is synchronized with the level displacement timing of a signal inputted to an external trigger terminal (not shown) or which passes for an arbitrary time from the timing.

[0071]

However, in a case of this type of sampling oscilloscope, a length of waveform (time range) which can be observed is determined by time resolution ΔTr and a capacity of a memory for storing waveform information, and in order to high-accurately detect a phase difference of the data signal Dr to be measured or the clock signal CK as described above, it is necessary to make time resolution ΔTr small.

[0072]

Accordingly, it is usually difficult to acquire or averaging-process all at once one frame of waveform information of the data signal Dr to be measured.

[0073]

Then, here, the acquisition start timing (acquisition range) of the waveform information of the data signal Dr to be measured and the clock signal CK are shifted by Q bits. Note that the shifted value Q may be a value less than or equal to the bit length of the waveform in which the waveform information can be acquired and averaged by small time resolution ΔTr as described above, and greater than or equal to 1.

[0074]

Shifting of the acquisition timing of the waveform information is achieved due to the frame synchronization signal S outputted from the pattern generating means 22 being delayed as the unit of time ($Q \cdot Tc$) corresponding to the Q bit length by a delay means 33, and due to the delayed frame synchronization signal Sd being inputted to the external trigger terminal of the sampling oscilloscope 32.

[0075]

On the other hand, the phase difference detecting unit 25,

(1) receives the waveform information of the data signal Dr′ to be measured and the clock signal CK′ which have been acquired and averaged by the sampling oscilloscope 32;

(2) determines Q bits of phase differences $\Delta T(i)'$, …, $\Delta T(i+Q-1)'$ these data signal Dr′ to be measured and clock

signal CK';

(3) increases the delay amount of the delay means 33 by Q bits, and shifts the acquisition region of the waveform information of the sampling oscilloscope 32 by Q bits with respect to the data signal Dr' to be measured and the clock signal CK;

(4) in this state, repeats the operation of receiving the waveform information of the data signal Dr' to be measured and the clock signal CK which have been acquired and averaged by the sampling oscilloscope 32, and determining the phase differences $\Delta T(i+Q)'$, ..., $\Delta T(i+2Q-1)'$ thereof; and

(5) in accordance therewith, determines phase differences $\Delta T(1)'$, $\Delta T(2)'$, ..., $\Delta T(N)'$ of one frame in the same way as in the above description.

[0076]

Information of the phase differences $\Delta T(1)'$, $\Delta T(2)'$, ..., $\Delta T(N)'$ for each bit obtained in this way are outputted to the band limiting processing means 26 in the same way as in the above description, and band limiting processing determined in advance in accordance with a bit rate is applied thereto. Then, the processed result is outputted to the measured result outputting unit 27, and the processed result is display-outputted, printed-out, or outputted to an external device, as the unit of time or UIpp units, as pattern dependent jitter Jdp which the measuring object 1 generates with respect to the data signal Dt.

[0077]

FIG. 8 shows a summary of the procedure of a method for

measuring pattern dependent jitter by using the sampling oscilloscope 32 described above.

[0078]

First, the clock signal CK having a predetermined frequency and the data signal Dt having a predetermined N bit length pattern which is synchronized with the clock signal CK, are provided to the measuring object 1 (step S11). Next, Q bits of the waveform information in the same time domain of the data signal Dr to be measured and the clock signal CK which have been emitted from the measuring object 1 and Optical-Electrical converted, are acquired (step S12).

[0079]

Next, averaging processing is carried out on the acquired waveform (step S13), and whereby random noise jitters are eliminated. Subsequently, Q bits of phase differences $\Delta T(i)$ of the clock signal CK′ and the data signal Dr′ to be measured are determined based on the waveforms obtained by the averaging processing (step S14).

[0080]

Hereinafter, due to the processings from step S12 to step S14 being repeatedly carried out N/Q times while the waveform acquisition range is shifted by Q bits (step S16), phase differences of all bits (one frame range) are obtained (step S15). Next, predetermined band limiting processing is carried out for the one frame amount information of the phase differences (step S17). Then, the measured result is outputted as the pattern dependent jitter of the measuring object 1 (step S18).

[0081]

Note that, as described above, in a case where the sampling oscilloscope 32 itself has a shifting function in which the acquisition timing (acquisition range) of waveform information is arbitrarily shifted, delay means is not provided at the exterior, and the acquisition timing of waveform information may be shifted by controlling the shifting function of the sampling oscilloscope by the phase difference detecting means 25.

[0082]

Further, in a case, as well, in which the shifting function in which the output timing of the frame synchronization signal S is shifted to the pattern generating means 22 side, delay means is not provided at the exterior, and the acquisition timing of waveform information can be shifted by controlling the shifting function of the oscilloscope 32 with the phase difference detecting means 25.

[0083]

Furthermore, in a case where the above-described shifting functions are provided in both of the sampling oscilloscope 32 and the pattern generating means 22, the acquisition timing of waveform information can be shifted by controlling the both with the phase difference detecting unit 25.

[0084]

For example, when the shifting function at the sampling oscilloscope 32 side can, in units of one bit, shift a number of bits up to a number of bits which is less than N (e.g., up to 16 bits) and the shifting function at the pattern generating

unit 22 side can shift in units of 16 bits, the following processing is carried out: 16 bits are shifted bit by bit in the shift function of the sampling oscilloscope 32 side and the phase difference of each bit is determined, and thereafter, the state returns to the initial state, and after shifting of 16 bits is carried out in the shifting function of the pattern generating means 22 side, 16 bits are again shifted bit by-bit in the shifting function of the sampling oscilloscope 32 side and the phase difference of each bit is determined.

[0085]

Moreover, when the sampling oscilloscope 32 has a function in which the phases of the two signals CK and Dr to be inputted can be relatively varied, due to the first level displacement timing of the data signal Dr to be measured being synchronized with the level displacement timing of the clock signal CK by controlling the function by the phase difference detecting means 25, the initial phase difference $\Delta T(1)$ described above can be set to 0. In this way, there is no need to carry out subtracting correction due to the initial phase difference $\Delta T(1)$ described above, and with respect to the following bits, a time difference of the level displacement timing of the clock signal CK and the level displacement timing (code varying timing) of the data signal Dr to be measured can be used as a phase difference as it is.

[0086]

In the above-described jitter measuring apparatus 20′, the electric data signal Dt is provided to the measuring object 1, and waveform information is acquired due to the optical

data signal Dp to be measured outputted from the measuring object 1 being converted into the electric data signal Dr to be measured. However, in a jitter measuring apparatus 20″ shown in FIG. 9, the data signal Dt is converted into the optical data signal Dt′ by an Electrical-Optical converter 35, and is provided to the measuring object 1 such as, for example, an optical amplifier from an output terminal 20e, and waveform information is acquired by converting the optical data signal Dp to be measured emitted from the measuring object 1 into the electric data signal Dr to be measured at the photoelectric converter 31.

[0087]

Further, in this case as well, when the sampling oscilloscope 32 has a function in which an optical signal is directly received and Optical-Electrical converted at the inside thereof, the Optical-Electrical converter 31 is omitted, and the optical data signal Dp to be measured can be directly inputted to the sampling oscilloscope 32.

[0088]

[Advantage of the Invention]

As described above, the jitter measuring apparatus and the measuring method of the present invention measure pattern dependent jitter by acquiring waveform information in the same time domain of a data signal to be measured and a clock signal; removing the random noise jitter component by averaging the waveform information; determining, for one frame, the per-bit phase difference of the clock signal and the data signal to be measured from which the random noise jitter has been removed;

and carrying out predetermined band limiting processing on this phase difference information.

[0089]

Therefore, only the pattern dependent jitter can be measured, which has been impossible in the eye-pattern observation of the prior art, and the association between a position of data and the pattern dependent jitter can be easily grasped.

[Brief Description of the Drawing(s)]

[FIG. 1]

FIG. 1 is A block diagram showing a configuration according to the invention.

[FIG. 2]

FIG. 2 is a drawing of a signal for explanation of the embodiment according to the present invention.

[FIG. 3]

FIG. 3 is a graph showing jitter waveform before frequency band limiting processing obtained according to the embodiment of the present invention.

[FIG. 4]

FIG. 4 is a graph showing jitter waveform after frequency band limiting processing obtained according to the embodiment of the present invention.

[FIG. 5]

FIG. 5 is a flowchart shown for explanation of measuring processing procedure of the embodiment.

[FIG. 6]

FIG. 6 is a block diagram showing a specific

configuration of an embodiment of the invention.

[FIG. 7]

FIG. 7 includes drawings for explanation of operations of a main portion of the embodiment corresponding to FIG. 6.

[FIG. 8]

FIG. 8 is a flowchart shown for explanation of processing procedure according to an embodiment.

[FIG. 9]

FIG. 9 is a block diagram showing a configuration of another embodiment.

[FIG. 10]

FIG. 10 is a block diagram showing a conventional jitter measuring system.

[FIG. 11]

FIG. 11 is a diagram for explanation of a conventional jitter measuring method.

[Explanation of Reference Symbols]

1 … Measuring object,

20, 20′, 20" … Jitter measuring apparatus,

21 … Clock generating means,

22 … Pattern generating means,

23 … Waveform information acquiring means,

24 … Averaging processing means,

25 … Phase difference detecting means,

26 … Band limiting processing means,

27 … Measured result outputting means,

31 … Optical-Electrical converter,

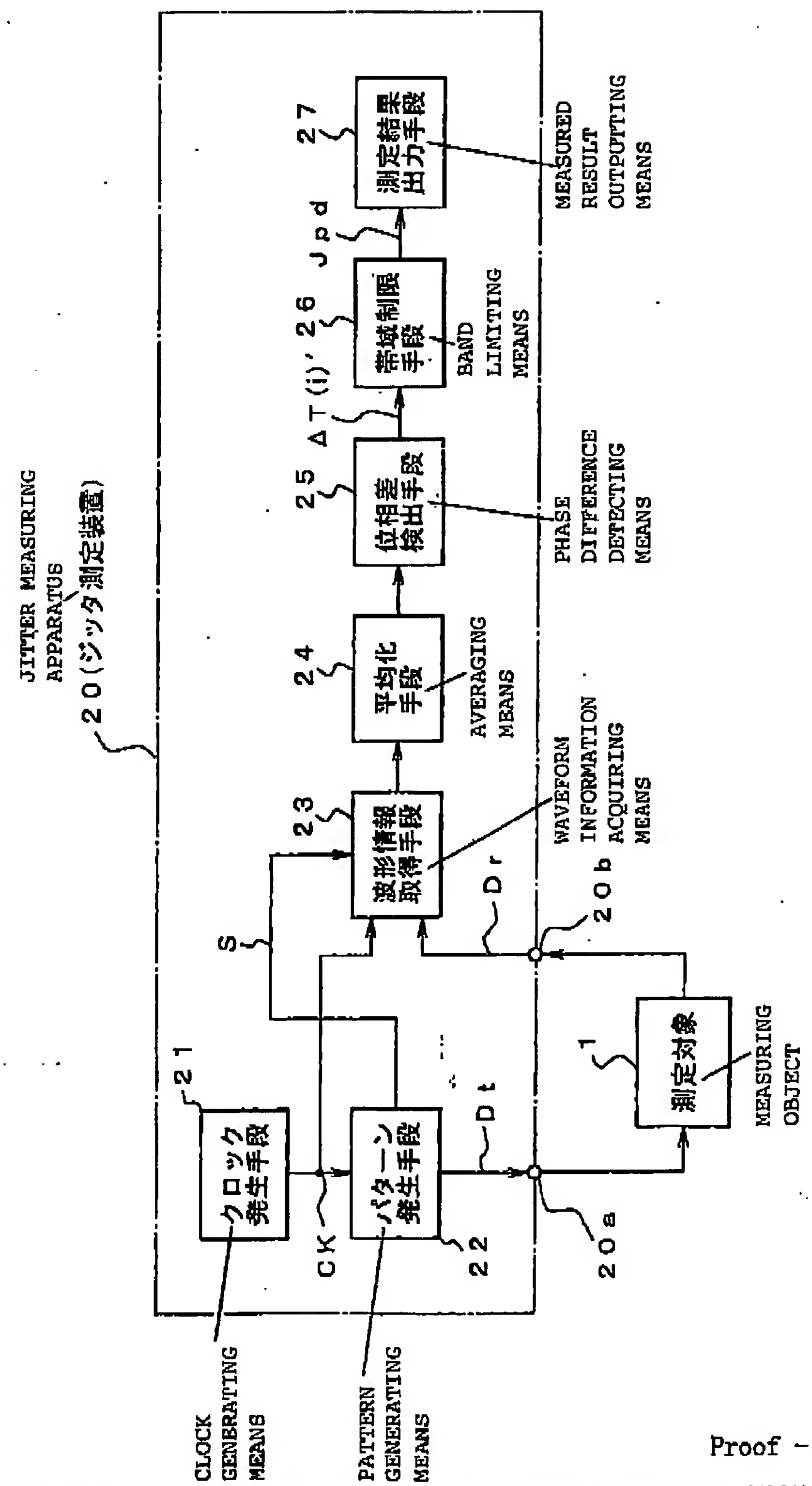
32 … Sampling oscilloscope,

33 ... Delay means,

35 ... Electrical-Optical converter.

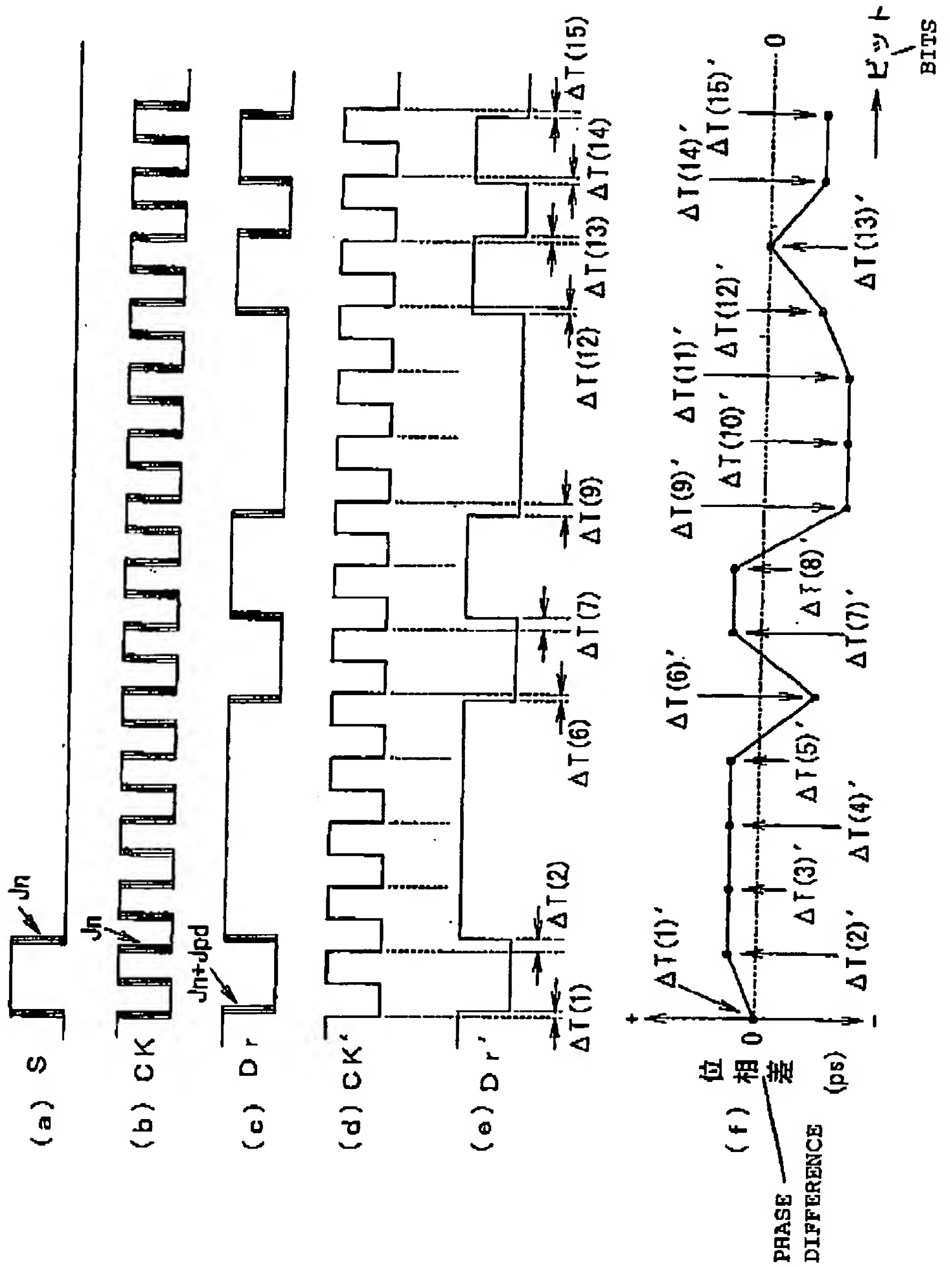
【書類名】 図面
[NAME OF DOCUMENT] DRAWINGS

【図1】
[FIG. 1]



Proof - 2002/12/17

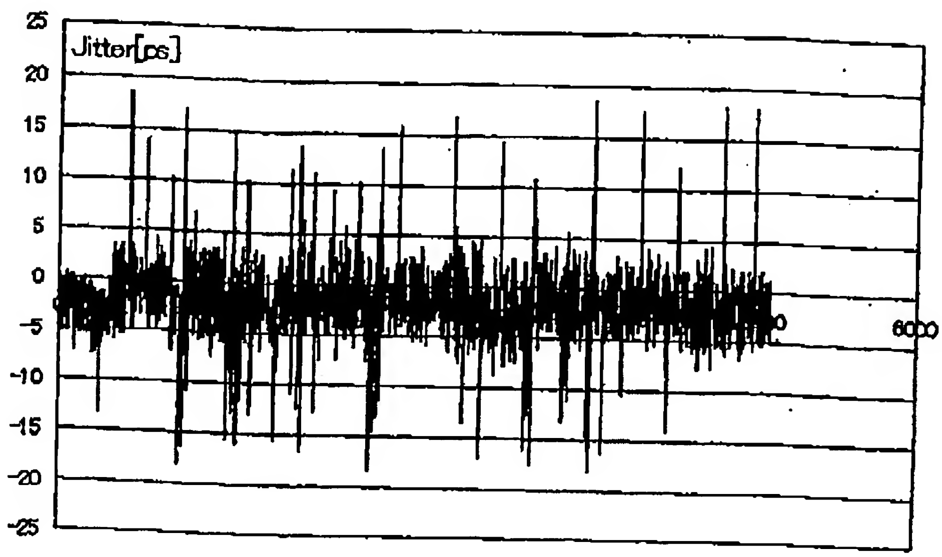
【図2】
[FIG. 2]



Proof - 2002/12/17

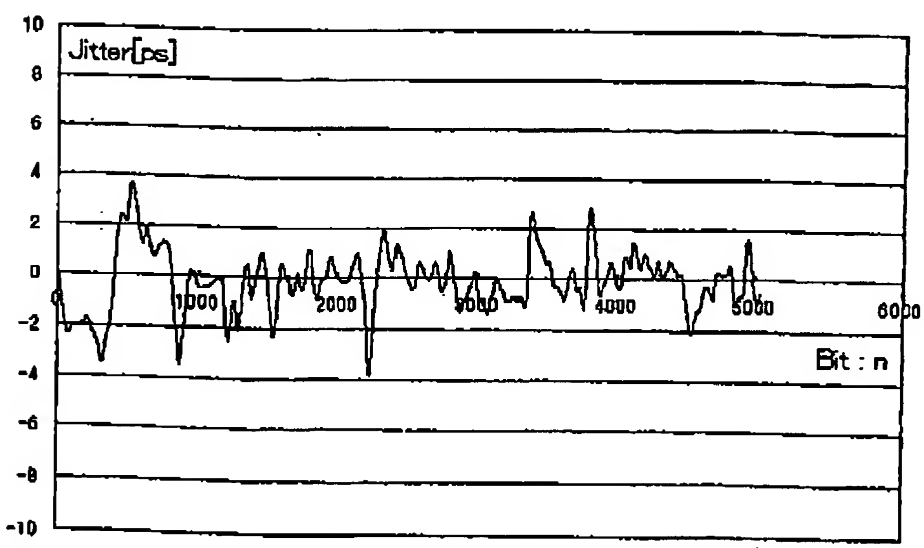
【図３】

[FIG. 3]



【図４】

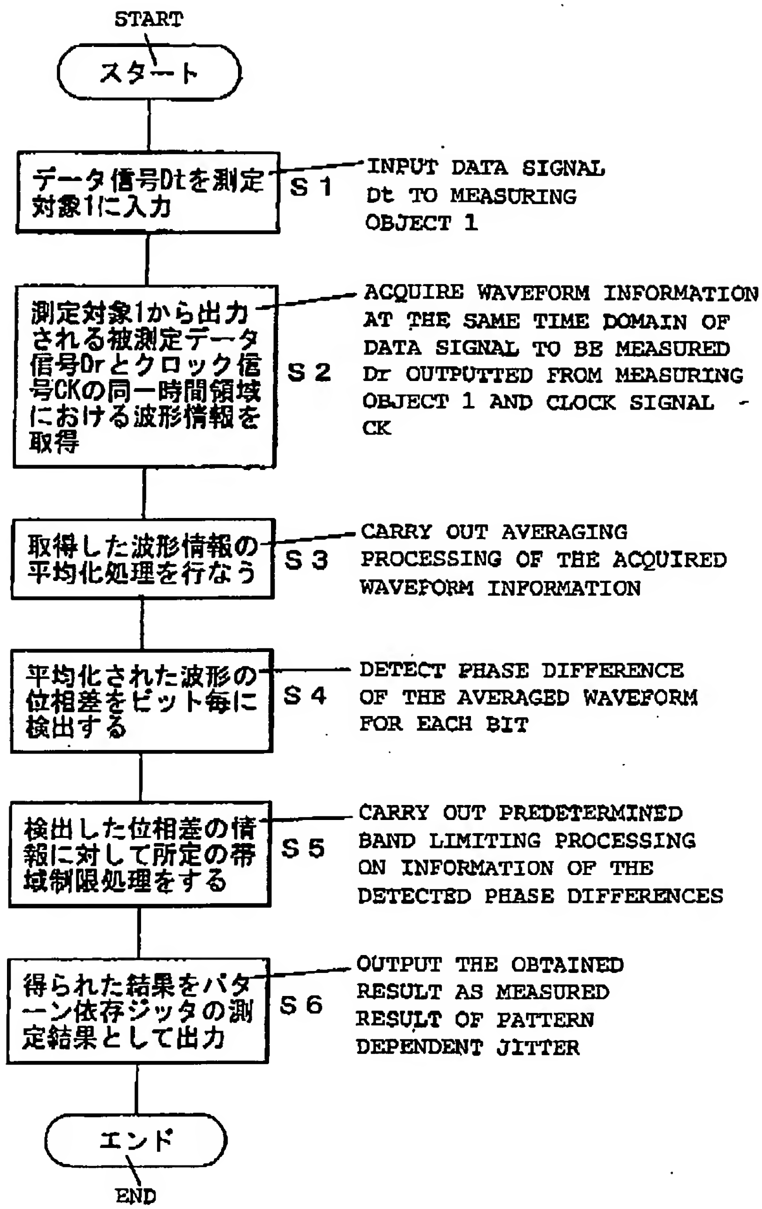
[FIG. 4]



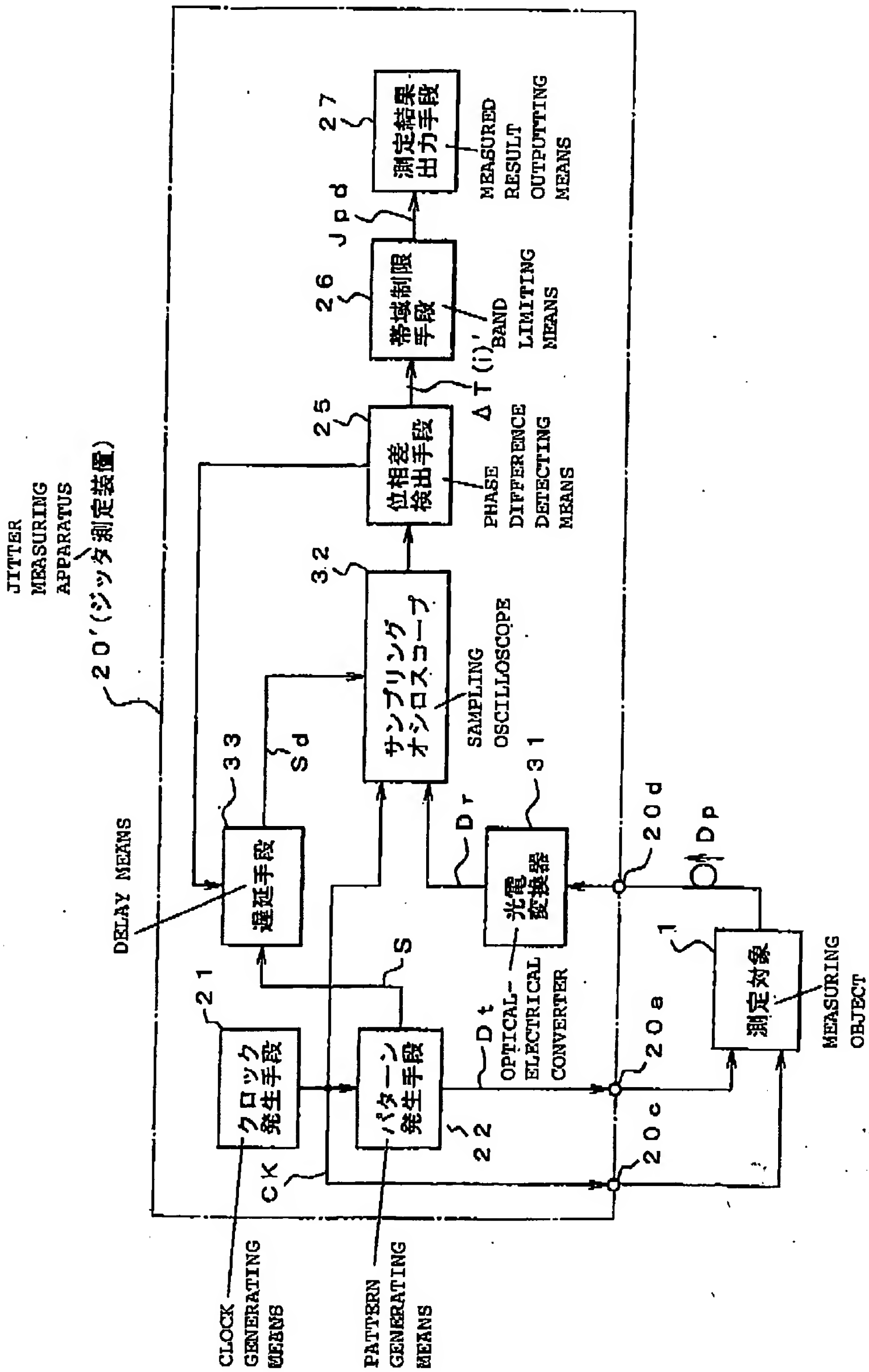
Proof - 2002/12/17

【図５】

[FIG. 5]


START
スタート
データ信号Dtを測定対象1に入力
S 1
INPUT DATA SIGNAL Dt TO MEASURING OBJECT 1
測定対象1から出力される被測定データ信号Drとクロック信号CKの同一時間領域における波形情報を取得
S 2
ACQUIRE WAVEFORM INFORMATION AT THE SAME TIME DOMAIN OF DATA SIGNAL TO BE MEASURED Dr OUTPUTTED FROM MEASURING OBJECT 1 AND CLOCK SIGNAL CK
取得した波形情報の平均化処理を行なう
S 3
CARRY OUT AVERAGING PROCESSING OF THE ACQUIRED WAVEFORM INFORMATION
平均化された波形の位相差をビット毎に検出する
S 4
DETECT PHASE DIFFERENCE OF THE AVERAGED WAVEFORM FOR EACH BIT
検出した位相差の情報に対して所定の帯域制限処理をする
S 5
CARRY OUT PREDETERMINED BAND LIMITING PROCESSING ON INFORMATION OF THE DETECTED PHASE DIFFERENCES
得られた結果をパターン依存ジッタの測定結果として出力
S 6
OUTPUT THE OBTAINED RESULT AS MEASURED RESULT OF PATTERN DEPENDENT JITTER
エンド
END

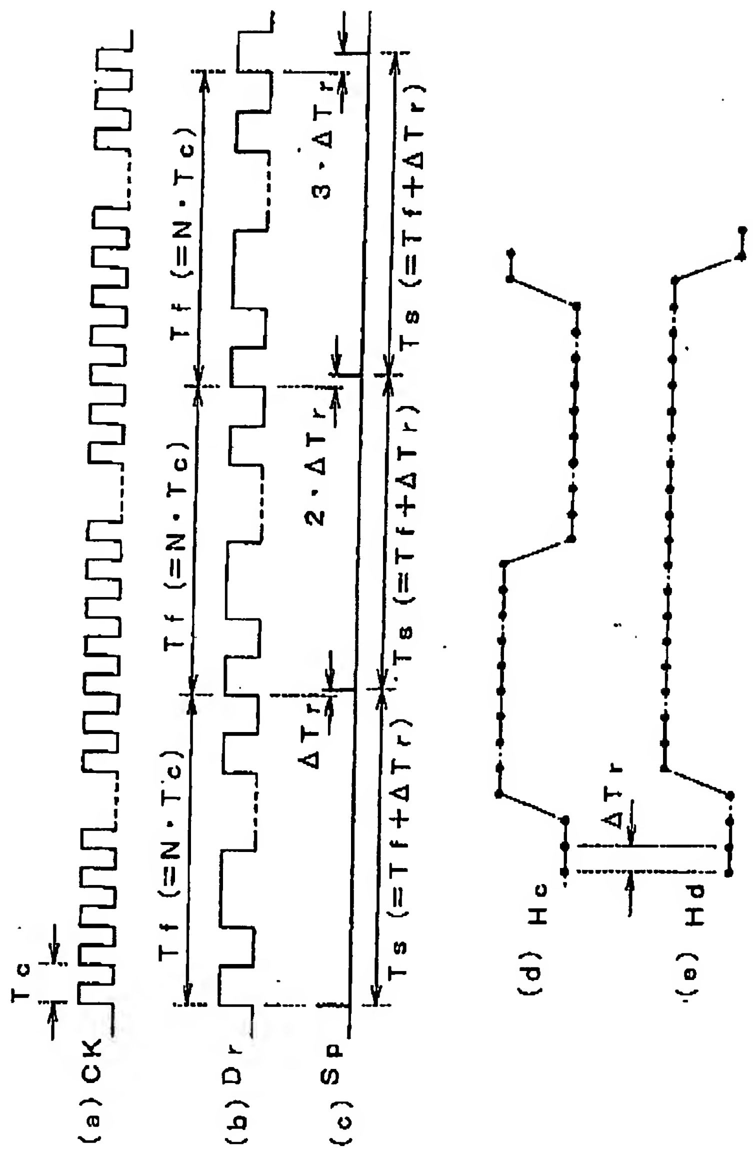
【図6】
[FIG. 6]



Proof - 2002/12/17

【図7】

[FIG. 7]



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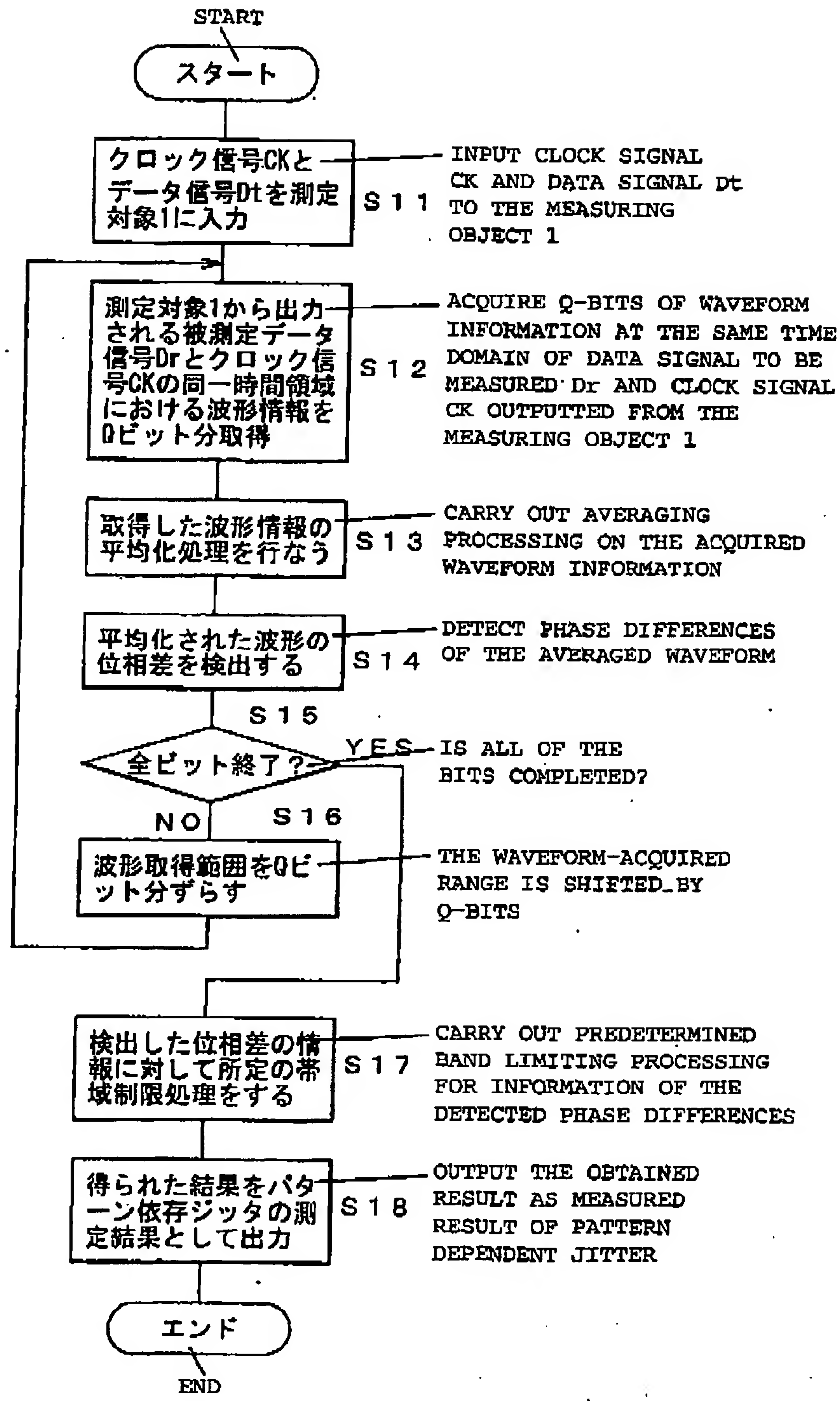
【図8】
[FIG. 8]



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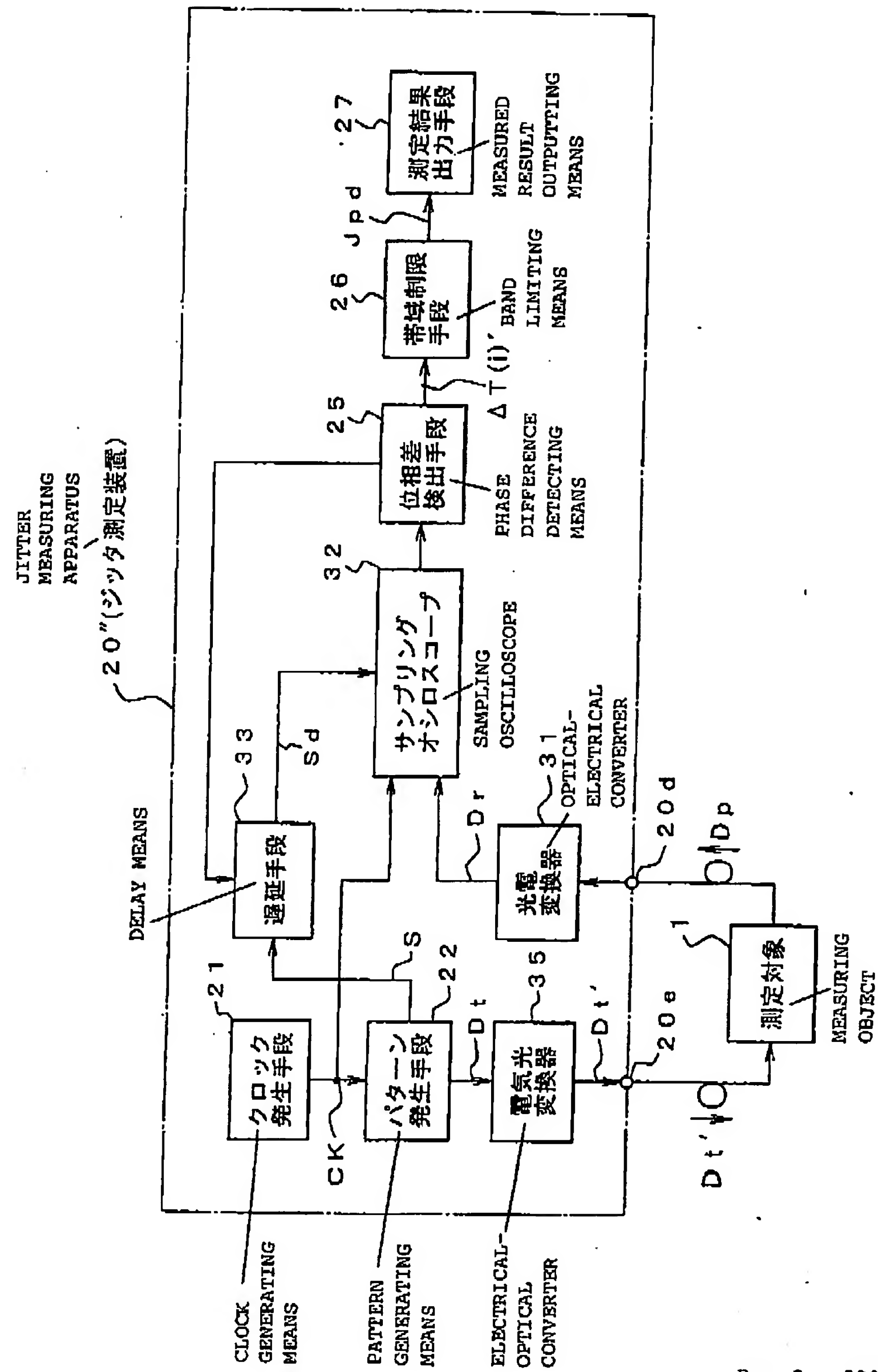
【図9】
[FIG. 9]



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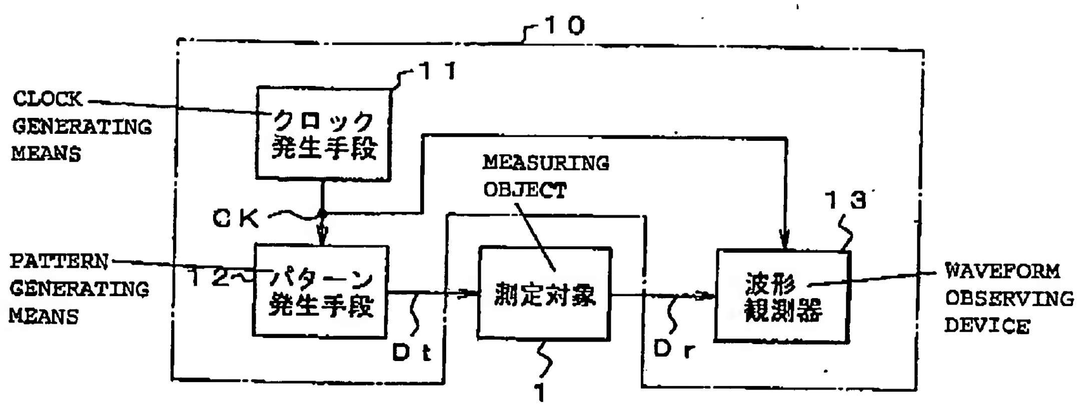
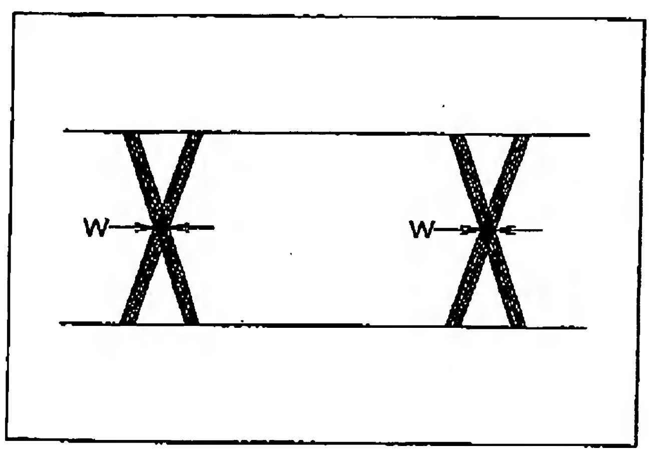
【図１０】

[FIG. 10]



【図１１】

[FIG. 11]



[Document] ABSTRACT

[Abstract]

[Object] The object of the present invention is to make it possible to exactly measure the pattern dependent jitter.

[Means for Achieving the Object(s)] The waveform information acquiring means 23 acquires information of waveform in the same time domain of a data signal to be measured Dr outputted from the measuring object 1, which has received a data signal Dt output from the pattern generating means 22, and a clock signal CK outputted from clock generating means 21. The averaging processing means 24 removes the random noise jitter component by averaging the waveform information. The phase difference detecting means 25 determines, for one frame, the per-bit phase difference of the clock signal and the data signal to be measured from which the random noise jitter has been removed. The band limiting processing means 26 carries out predetermined band limiting processing on the phase difference information obtained by the phase difference detecting means 25. The measured result outputting means 27 outputs result of the band limiting processing to the data signal Dt as pattern dependent jitter generated from the measuring object 1.

[Elected Figure] FIG. 1